Backflow Technology: Design to Commissioning

By Bruce Parrot

As plumbing engineers, you've no doubt heard the common refrain: an unprotected cross connection jeopardizes public health. Just one unprotected cross-connection can cause serious injury, or death. Yet, somehow, these and other widely accepted tenets are ignored routinely, causing loss of lives and commercial enterprise.

We hear the horror stories all the time. I recall that, while receiving treatment at an Illinois hospital, a man died when his kidney dialysis machine became contaminated with antifreeze from an air conditioning system. Less than a year later, the same thing happened in New York, leading to the death of a young woman. More recently, liquid propane leaked into a town's water supply in Connecticut during unauthorized maintenance by a utility company. Explosions rocked the sleepy community; there were fires and severe injuries and millions were spent on the cleanup. And in Alabama, sodium hydroxide from a chemical plant backflowed into a town's drinking water supply. We could fill a book with these stories. Clearly, these are high-risk conditions.

Backflow prevention is the vanguard of clean water, for both critical- (health hazard) and low- (non-health hazard) risk water supplies. Stated simply, backflow is the unwanted reverse flow of liquid in a piping system. Grey water or any other source of contamination can enter a potable water supply whenever outlet pressure or system pressure becomes greater than supply pressure. The risk is especially high at cross-connection points - the physical connection between two separate piping systems where one contains safe drinking water and the other a potential contaminant or pollutant.

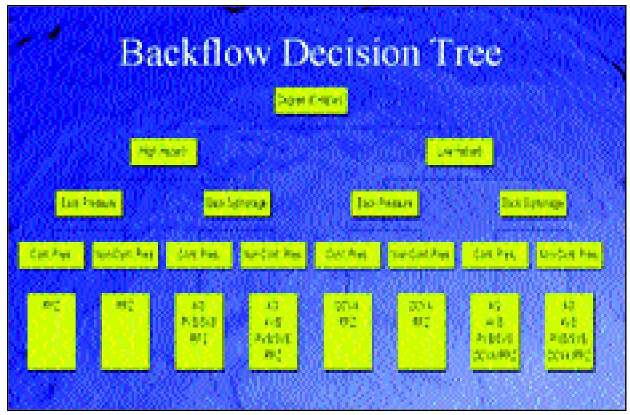
Without question, cross-connections are an integral part of all facilities with plumbing systems. The danger comes from cross-connections that are insufficiently protected or are unprotected.

In this article, I'll discuss both health and non-health situations, how they're generally differentiated and what techniques and technology are used to protect potable water supplies. We'll then go to advice from one of the industry's leading experts, Bernie Clarke, who readily shares new concepts that could dramatically transform an industry that's slow to change.

Degree of Hazard

A substance that is drawn into a potable water supply is either toxic or non-toxic. It could be anything from rusty water, highly concentrated pesticide or even bloody wash from an autopsy table. When determining the protection needed at any cross connection, the key concern is the toxicity level of the possible contaminant (*see chart*, Backflow Decision Tree).

"Degree of hazard" defines the levels of cross-connection risk. All methods and devices are rated for non-health haz-



ard use, health hazard use or for a combination of both.

The type of backflow assembly to be used varies according to the type of substance that may be at risk of flowing into a clean water supply. A "pollutant" may be any substance that will affect the color or odor of water, but will not necessarily pose a health hazard. Atrue health hazard exists when a substance, or "contaminant," if ingested, could cause illness or death.

The two key factors in determining which backflow assembly is best suited to the application are the degree of hazard and system hydraulics. The hydraulics of the system indicates whether a back-siphonage, back-pressure or a continuous pressure device is needed. In back-siphonage, reverse flow is caused by negative pressure, or vacuum, in the supply piping. In back-pressure, reverse flow happens when the downstream pressure is greater than the supply pressure.

Today, the degree of hazard is seen as the determining factor in choosing which type of backflow assembly should be used to protect a water supply. These are broken into several categories, or methods of backflow prevention:

1. An air gap is the physical separation – by an air space – of drinking water and a potential source of contamination. Air gaps, for good reason, are applied in only those instances where the loss of system pressure is acceptable (laundry sinks, for instance).

2. Double check valve assemblies (DCVAs) consist of two independent check valves. They protect against back-siphonage or back-pressure when at least one check is holding. This type of valve is used under continuous pressure, non-health hazard connections. Typical uses of these devices include food processing equipment, lawn sprinklers, non-toxic fire sprinkler systems, commercial swimming pools and similar applications.

A related device, the double check detector valve is applied to prevent the reverse-flow of fire protection systems.

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These assemblies are installed in fire sprinkler lines and detect underground leaks or the unauthorized use of unmetered water.

3. A pressure vacuum breaker is used on connections to non-potable systems. It protects against back-siphonage, but not against back-pressure. It may be used under continuous pressure, and for non-health or health hazard connections. Typical applications include irrigation and turf sprinkler systems, laboratory equipment and commercial laundry equipment.

4. An atmospheric vacuum breaker (AVB) is used only on cross connections where back-siphonage is a potential hazard. It does not protect against back-pressure. The device is always placed downstream from all shut-off valves, both manual and electric. A downstream shutoff valve, if closed, would keep the assembly under continuous pressure and may cause the air inlet seal to mate to the bonnet, preventing the vacuum breaker function from operating. That is, you just installed (or specified) an expensive pipe elbow.

The AVB's air inlet valve closes when water flows in the normal, anticipated direction. But as water ceases to flow, the air inlet valve opens, eliminating the possibility of back siphonage by introducing air into the downstream piping.

This type of assembly must always be installed at least 6" above all downstream piping and outlets. If attached piping were to run to points of higher elevation, back pressure will keep the air inlet valve closed, disabling its ability to protect the water supply.

Unlike a pressure vacuum breaker, the atmospheric type cannot be used under continuous pressure. But like the pressure vacuum breaker, the atmospheric type protects against both non-health and health hazard cross connections.

5. A reduced pressure zone backflow preventer (RPZ) delivers the highest level of protection against backflow and is typically applied in health-hazard cross connections. An RPZ can be used on all direct connections subject to back-siphonage or back-pressure, or a combination of the two, and on systems operating under continuous pressure.

Some field conditions often begin as a back-siphonage condition that may then stir up debris in the water, causing the checks to foul. With both checks fouled, you now must rely on the discharge capacity of the relief valve to safeguard the water supply. Essentially, higher discharge rates equal added protection for the water supply. Typical RPZ installations include main supply lines, boiler feedlines, autopsy tables, medical aspirators, and other health hazard cross connections.

6. Watts and other suppliers also make a variety of specialty backflow preventers for point-of-use applications.

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Sizing & Selection

Backflow preventers are sized to be line-sized. That is, they should be of the same size as the water supply connection. Selection criteria are based on the degree of hazard present and the system application. Examples of typical installations include:

- Garbage can washer – dual check with atmospheric vent
- Janitor sink – hose bibb vacuum breaker
- Chemical dispensing equipment – spill resistant vacuum breaker
- Drinking fountain – air gap
- Carbonated beverage machines – stainless steel dual check with vent
- Cooling towers – reduced pressure backflow preventer

Design Considerations

One of the most common installation problems involves the potential discharge of water from the reduced pressure style backflow preventer. Over the course of the life of the backflow preventer, it's only a matter of time before some sort of mechanical failure happens. It may be something as simple as dirt or rust sourced and stirred up from a local construction project, or debris that moves in on the assembly following the flushing of a fire hydrant by the water authority. Or, after 20 years of service, the check disc rubber may need to be replaced.

Whatever the reason, it's not a matter of if you will experience discharge of water from a reduced pressure backflow preventer, but when. Care should be taken to insure that adequate floor drain capacity is specified to allow the discharge of water from the relief valve of the RPZ . Several manufacturers offer flood protection systems that can be specified to shut off the incoming water supply to the backflow preventer. Most of these systems use an automatic control valve that is located upstream of the RPZ and is automatically closed when water is discharged from the relief valve.

Flooded With Risk

Consider this recent legal case in Southern California. While working in a medical facility, a plumbing contractor had turned off the water main for a short time. He was unaware that nurses had partially closed the supply valve to a vacuum breaker, starving flow to the backflow assembly. The unit leaked, undetected, for days. It flooded three floors of the building, effectively closing six doctor's offices for six months. Needless to say, a substantial lawsuit followed.

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Yet, why are we shutting down water service, especially to buildings where water service is critical, such as in restaurants, hospitals, schools and clinical facilities? It's not necessary. Designers and engineers need to know there's now a better way. The pressure regulator doesn't need to go into the building. Put it with the backflow preventer (if winter conditions permit it). This lets the water customer have uniform pressure at the needed flow rate.

Accomplishing this has never been easier. The industry is gradually moving toward the dual or parallel backflow assembly. One of the most passionate champions of this technology is Bernie Clarke, owner of Clarke Sales and Backflow Prevention Device Tester, based in Valencia, Calif., and recognized as one of America's leading backflow experts. In Southern California, Bernie has designed and installed many fully redundant, dual backflow assemblies His technique merits attention. Clarke's solution to many complex applications is to combine the pressure regulator and other components into one, fully redundant valve station. It accomplishes several things:

1. It eliminates the need to provide a designated room for the components.

2. Mainline with 24 hours of high pressure on it going to various buildings containing their own set of regulators inside. This reduces the pressure at the backflow preventer and in turn reduces the high pressure in the mainline throughout the facility.

3. The use of the Automatic Control Valve (ACV) for regulating of pressure to facilities is the best way to optimize the pressure range. The ACV has a higher range of pressure and can hold design operation pressure consistently when more flow is needed.

4. The redundant use of several direct acting (DA) regulators in parallel to get the optimal flow range. One ACV will hold the design pressure when flowing of more demand is called for. The DA regulator will lower pressure as more flow is called for.

5. The need for a regulator in an irrigation system: pressure is generally adequate because the flow pressure drop is not there.

6. The backflow tester can test the backflow assembly without interrupting water flow to the building, have the time to perform quality repairs and, if necessary, change station components with no interruption in service or regulated pressure.

Generally, the design is to meet backflow requirements – a 3" water line means 3" backflow assembly (BFA), and so on. Unfortunately, says Bernie, there's little or no forethought given to the after-design and common problems such as interruption of water service to the building, and tenants, during testing and repairs, or problems stemming from deteriorating water lines.

Bernie encourages all backflow experts in the field, and on the maintenance side, to get creative. Here's what's working for him in the Los Angeles region: He designs a combination of two BFA sized to meet the flow, not one. If the water line is a 3", then two 2" BFAs would be designed to meet the flow. It would be in the customer's best interest to use a 2" BFA (where possible) for low maintenance and a longer life span. This establishes a better design with the brass and ball valves rather than flanged iron and gate valves.

He installs backflows, regulators, strainers, etc., on the system's point of connection (POC) from the water meter, rather than the common practice of scattering the components from various manufacturers in various locations throughout the water line. By installing the components at the POC, you increase awareness of what is right and compatible for the system to all who operate and maintain the system. This way, there's only one installation of all components. There is only one manufacturer of all components, and total compatibility. The owner is rarely burdened with the disruption of service for high pressure BFA testing, repairs, or other vectors of influence.

Clarke asks, "How many times do water purveyors shut off the water to the street for quick repairs?" Finally, when the water is turned on to the building, the one and only BFA supplying water is negatively affected by the transition and requires an experienced and knowledgeable tester to bring the system back to operable conditions. The bottom line is a "delay of the game" and inconvenience to everyone involved.

There are many issues that can be addressed more effectively if only more thought is afforded in the beginning of the design. Clarke encourages all of us to consider several points. First, why would anyone design a water system to a complex of importance and have it be subjected to water shut off? Second, who shares the cost of major liability for flooding to the building when the water is turned on? Lastly, are all parties notified of their responsibility and do they know the contents of the entire building that are affected during the water shut off?

Clarke's advice is sound, and his interests are directed at improving the overall good for those who engineer the systems, install and test them, and those whose operations, profitability and livelihood depend on the unfailing, round-the-clock performance of backflow technology. ❑

About the Author

Bruce Parrott is marketing manager, Backflow Products, for Watts Water Technologies. He has more than 10 years of sales experience in the automatic control valve business. His career started in the waterworks industry with a control valve manufacturer, specifying and selling products for waterworks, fire protection, irrigation and more.